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TECHNICAL REPORT NO. 74-58

OURCE SMOKE AND RIOT CONTROL AGENT ROPE

by

John D. Buchanan
Munitions Branch

April 1974

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Final Report

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Aberdeen Proving Ground, Maryland 21005

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Smoke
Rope
CS
Crowd Control
Control Agent
Dispenser

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is the final report on the Line Source Smoke and Riot Control Agent Rope program. The purpose of this program was to improve the characteristics of a commercially available smoke rope to provide increased value to the US Army as a crowd control device.

The "smoke rope' may be laid out across roads, in front of buildings or natural terrain features to produce a one shot smoke screen. The smoke screen may be inert or may contain CS or a similar control agent. A number of lines

Continued on reverse

BLOCK 20. ABSTRACT CON'T

may be laid side by side so a repeatable barrier effect may be achieved. The final design was tested by Dugway Proving Ground under TECOM Project No. 5-WE-FOO-RCR-001. Their letter report of the test results was published under that project number.

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INTRODUCTION

Presently available means for controlling a crowd or denying particular areas to crowds are not effective. The use of smoke and/or riot control agent in rope form is a new and effective method of crowd control and building or area denial which should help overcome deficiencies of present methods.

The smoke rope is essentially a thin plastic tube filled with an irritant (CS) pyrotechnic composition and an inner-fuze wire which burns the chemical filler. It is approximately 3/8 inch in diameter and weighs 25 grams per foot. It contains approximately 3.3 grams of CS per foot, and produces a white smoke. It may be made in any length; however the standard package sold by the manufacturer is 250 ft.

DEVELOPMENT AND TESTING

General

In July 1972, the US Army Land Warfare Laboratory initiated Task 03-F-73 to procure and conduct Engineer Design Tests (EDT) on a commercial smoke rope developed and manufactured by the Ensign Bickford Company, Simsbury, CT.

Investigation into the specifications of the smoke rope indicated that it was desirable to increase the burn rate so that a member of a crowd could not outrun the cord after ignition. In addition, it was desirable to increase the quantity of smoke produced and to increase the burning time. Photographs of the packaged material and the smoke cloud produced are shown in Figures 1-5.

In addition to the irritant chemical (CS), the composition contains a white smoke formulation consisting of ammonium perchlorate, ammonium chloride and zinc oxide. One of the combustion products of the burning smoke rope is zinc chloride. Long term exposure to zinc chloride may result in lung damage. Personnel using or testing the rope should use the M-9 Protective Mask with the M-11 Canister.

Performance tests to determine igniter functioning, burn rate, quantity of smoke produced, tendency to start fires and tendency to self-ignite were prepared (Appendix A).

Figure 1. Package as a Carrying Case

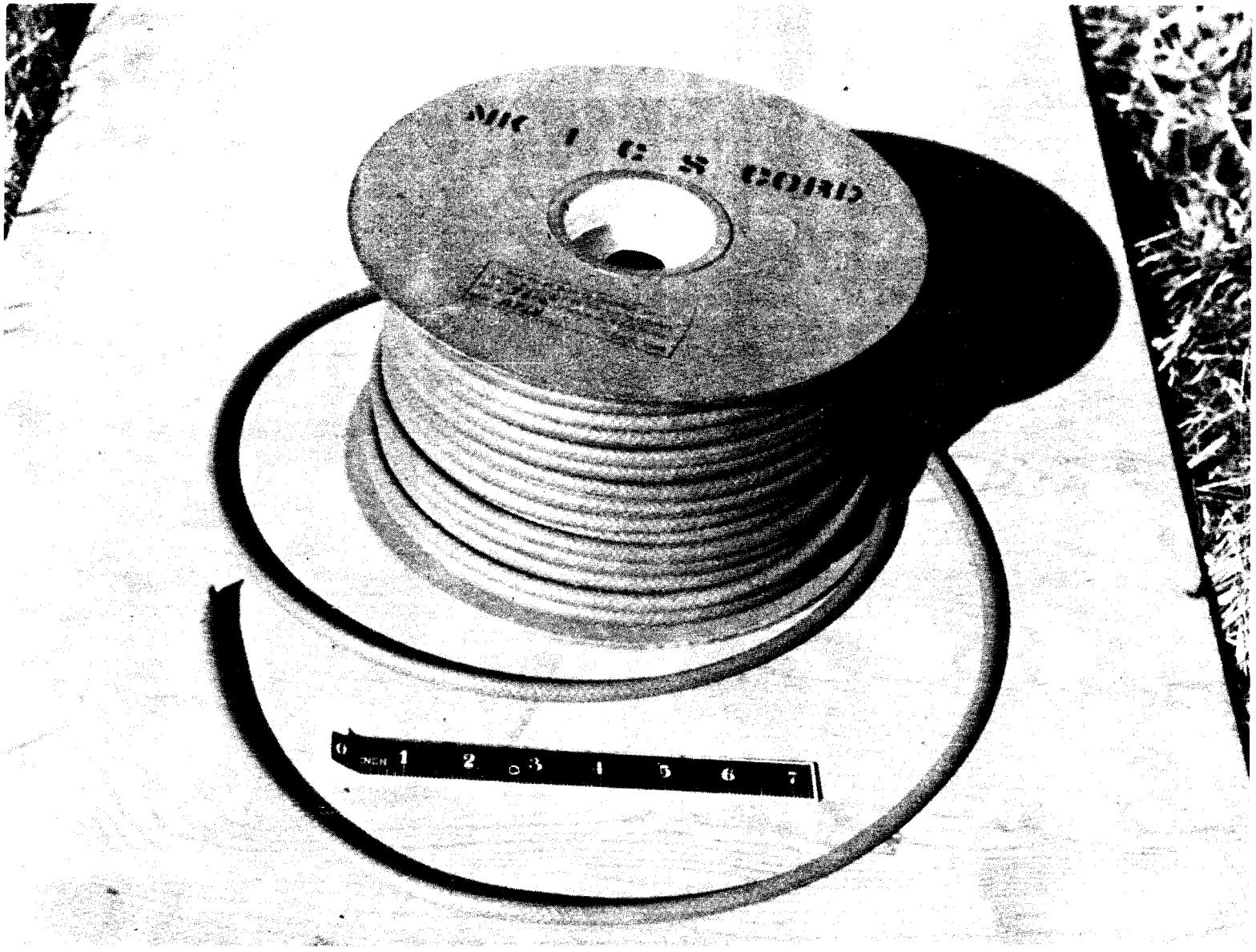

Figure 2. Reel of Smoke Rope

Figure 3. Components of Package

Figure 4. Initial Burning

Figure 5. Smoke Cloud Produced by Smoke Rope

Testing and Test Results

The data obtained from the performance and environmental test are presented in Appendix B.

Results of Performance Tests:

1. Igniter Functioning: During testing by Ensign Bickford, igniters which had been stored at +160°F, all (6 out of 6) failed to ignite. Investigation indicated that the asphalt base chemical in the burn train of their igniters melted at 150°F. When replaced with an asphalt base chemical with a melting point of 185°F, the igniters (40 out of 40) functioned properly after 160°F storage and all 175 of those tested at ambient temperature functioned properly.

2. Smoke Rope Ignition: All Smoke Ropes ignited when initiated.

3. Burn Rate: All Smoke Rope sections burned with a rate in excess of 15 ft per second except one lot which had been stored at +160°F. After discussion it was decided to change the specifications so that the maximum storage temperature for the Smoke Rope would be specified at +145°F.

4. Quantity of Smoke: This was essentially impossible to measure accurately; however a 10 ft x 10 ft wood frame was erected above the smoke rope. From visible judgment a cloud at least 15' x 15' seemed to be present two seconds after ignition.

5. Tendency to Start Grass Fires: This test was designed to determine the tendency of the Smoke Rope to cause grass fires. The test consisted of laying 50 ft of smoke rope on a thick layer of dry straw. No burning of the straw resulted as long as the rope was on top of the straw. When straw was placed below and on top of the rope, one fire resulted after approximately 10 minutes of smoldering. Because of the low burn temperature of the chemicals (estimated to be between 300 - 400°F) there is actually a low tendency to cause grass fires.

6. Tendency to Self Ignite: This performance test was designed to determine the practicality of placing a number of Smoke Ropes close to each other in order to have a repeatable barrier effect. These tests indicated that only one in five Smoke Ropes would self ignite when two ropes were taped together.

Result of Environmental Tests: The requirements, as verified by the environmental tests outlined in Appendix A, were met except for that of storage. To prevent deterioration of the burn rate of the "Smoke Rope" the maximum storage temperature was reduced from +160°F to 145°F.

CONCLUSIONS

The Line Source Smoke and Riot Control Agent Rope met all the performance and environmental tests established and has shown that it can be stored and used in categories 1 through 7 of AR70-38 except that high temperature storage must be reduced from 160°F max. to 145°F max. in order to prevent deterioration of the burn rate. If a faster burn rate is considered essential it does appear to be within the "state-of-the-art."

APPENDIX A

PERFORMANCE AND ENVIRONMENTAL TESTS

APPENDIX A

LINE SOURCE SMOKE AND RIOT CONTROL AGENT ROPE ENGINEER DESIGN TEST (EDT) PROJECT 03-F-73

I. Test Objective

To perform an Engineer Design Test (EDT) on the "Smoke Rope" containing a control agent (CS).

II. Background

The Army is interested in crowd control and denial of areas and buildings to crowds. This control agent in a smoke rope form may be used to block off streets, areas, and buildings from crowds. The lines must be emplaced prior to usage. Several lines may be installed in close proximity in order to obtain a "repeatable barrier" effect. In addition, lines may be placed in front of or behind erected barriers, natural terrain or vegetation barriers, or building, or structures to reduce the effect of wind velocity to disperse the smoke produced.

III. Description

The Control Agent Smoke Rope is 3/8 inch in diameter. It contains 3.3 grams of CS ~~per foot~~ and weighs a total of 25 grams per foot. The cross section of the rope consists of an ignition wire (safety fuze) surrounded by the smoke-producing chemical. The fuze and smoke-producing chemicals have a plastic wrap which is colored blue (CS smoke) and yellow (plain smoke).

The rope is furnished in 250 foot lengths which are coiled in corrugated fiberboard boxes. The box is designed as a carrying case and a dispenser. Each rope contains five (5) 8-second delay fuze igniters. The Control Agent Smoke Rope has the following characteristics:

Diameter	3/8 inch
CS Load	3.3 $\pm$ .5 grams per foot
Smoke Charge	16.5 $\pm$ 2.5 grams per foot
Total Weight	25 $\pm$ 5 grams per foot
Ignition Rate	15 ft/sec minimum
Burn Time	2 sec minimum
Tensile Strength	114 lbs minimum
Shelf Life	3 years minimum
Cord Color	Blue (CS smoke) Yellow (plain smoke)
Method of Ignition	Pull wire fuze with 5-sec delay
Smoke Color	White
Handling	Plain Smoke Rope is safe to handle, store, and use. See Section VI for CS smoke.

IV. Classification

The item is unclassified.

V. Report

Letter Report

VI. Safety

No hazards in the item other than those normal to smoke-producing pyrotechnics for the smoke rope. However, the smoke rope containing CS will require special handling procedures normal to those associated with CS-producing grenades or similar devices. The combination of Ammonium Chloride and Zinc Oxide will produce Zinc Chloride. Long term exposure may result in Alkali damage to lungs and death. Personnel using or testing the smoke rope should use the M-9 Protective Mask with the M-11 Canister.

VII. Test Plan

A. Performance Tests

1. Determine the rate of ignition of the Control Agent Smoke Rope along its length. This rate shall be a minimum of 15 ft/sec and may be determined by stopwatch measurement of the time required to burn a 50-foot length.

2. Determine the total burn time of the chemicals in the rope after it has been ignited. The burn time shall be a minimum of 2 seconds after ignition.

3. Determine the amount of CS aerosolized per unit of length. The amount of CS aerosolized shall be a minimum of 1.5 grams per foot. Tests to be conducted by sampling the aerosolized product from a test chamber and running a chemical analysis of the product.

4. Determine the amount of CS remaining in the burned residual. The residue shall not contain more than 0.5 grams of CS per foot.

5. Determine how often the smoke rope will start grass fires in dry, grassy areas out of ten burnings of 50-feet of rope.

6. Determine how close one smoke rope may be to another and not self-ignite when one of the ropes is burned using the Bruceton method of sympathetic ignition.

B. Environmental and Handling Tests

1. Temperature Storage: The smoke rope and ignition devices will undergo at 160°F high temperature storage in accordance with AR 70-38, 7 day, 4 hours at 160°F and 20 hours at 125°F. The low temperature tests will be 7 days, 6 hours at -25°F; alternate 6 hour intervals will be used for temperature changes from -5°F to -25°F and the reverse. After storage, the smoke rope will be fired for performance rating at ambient temperature (+50°F to +90°F).

2. Transportation: The smoke rope and ignition devices will be vibrated at +160°F and -70°F in accordance with MTP 4-2-804. The criteria for passing this test is that the smoke rope remain safe and operable at ambient temperature (+50°F to +90°F).

3. Five-Foot Drop: The smoke rope and ignition devices will be tested in accordance with MIL-STD-331, Test III at +160°F, +60°F and +32°F. The criteria for passing this test is that the smoke rope and ignition devices remain safe and operable at ambient temperatures (+50°F to +90°F).

4. Forty-Foot Drop: The smoke rope and ignition devices packed and packaged in their shipping containers will be dropped one time from a height of 40 feet at ambient temperature (+50°F to +90°F) to impact on steel plate. The drop orientations will be bottom down, top down, and top corner down. The criteria for passing this test is that the smoke rope and ignition devices neither burn nor detonate on impact and that they be safe to handle for disposal purposes.

5. Humidity: The smoke rope and ignition devices will be subject to the temperature and humidity test outlined in MTP 4-2-820. At the completion of this test the smoke rope and ignition devices will be inspected for evidence of leakage and damage. After examination, they will be tested for performance rating at ambient temperature (+50°F to +90°F).

APPENDIX B

ENSIGN BICKFORD FINAL REPORT

CONTRACT NO: DAAD05-73-C-0491	ISSUED BY: AB Proving Ground	ADMINISTERED BY: DAS #50701A33008PL ✓

ITEM NO:	DATA REQUIREMENT:	REPORT PERIOD:	REPORT NO:
A004	Final Report - Phase I, Phase II and Phase III	N/A	1

CONTRACTOR:	SUBMITTED BY:	DATE:	PAGE
The Ensign-Bickford Company 660 Hopmeadow St., Simsbury, CT 06070	Michael T. Long Contract Administrator	November 29,1973	1 OF 3

AIMS & OBJECTIVES

The object of this program was to develop a riot control agent in the form of a rope for use by the Army in controlling crowds and denying access to streets or buildings. E-B's original riot control cord had properties that did not meet military requirements, such as: burn rate, no flaming during burning, amount of CS aerosolized, and amount of smoke generated. This contract was initiated to develop the existing product to meet military requirements and furnish 35,000 feet.

EXPERIMENTAL

The two most difficult requirements were ignition rate (15'/sec min) and the amount of CS aerosolized (1.5 gm/ft min). The initial effort was directed at meeting these two requirements.

B-2

1. Ignition Rate - This was accomplished by increasing the confinement of the smoke charge by double-taping and countering. Changing the tape from polyethylene to Saran eliminated flaming during burning as Saran is a self-extinguishing plastic. The ignition rate was determined to be between 20 and 30 feet per second.

2. CS Aerosolization - Samples of smoke were collected in our test chamber and analysis for CS content was performed on a Beckman DK-2 Ratio Recording Spectrometer. Difficulties were encountered because of solvent impurities and the solvent was changed from methylene chloride to methyl alcohol. Peak absorbtion occurred at a wave length of 298 millimicrons and this wave length was used for comparison between standards and unknowns. The amount of CS aerosolized was determined to be between 2.0 and 3.0 gm/ft. This corresponds to a coreload of 16.5 gm/ft with 20% CS by weight (3.3 gm CS/ft). No CS was found to be present in the residue.

   Remaining Specifications - Accomplishment of the two main goals resulted in a product having the properties shown in Appendix I. These properties meet the contract specifications.

CONTRACT NO: DAAD05-73-C-0491	ISSUED BY: AB Proving Ground	ADMINISTERED BY:

ITEM NO:	DATA REQUIREMENT:	REPORT PERIOD:	REPORT NO:
A004	Final Report - Phase I, Phase II and Phase III	N/A	1

CONTRACTOR: The Ensign-Bickford Company 660 Hopmeadow St., Simsbury, CT 06070	SUBMITTED BY: Michael T. Long Contract Administrator	DATE: November 29,1973	PAGE 2 OF 3

TESTING

Samples meeting the above physical specifications were sent to General Environments Corporation, Springfield, Virginia, for the specified Environmental and Handling Tests (Appendix V). Following these tests, Performance Tests were conducted in Simsbury with John Buchanan of Aberdeen Proving Ground as a witness. A summary of the results is listed in Appendix II and III.

1. Igniters - Nine of the 70 igniters failed to ignited the smoke rope. Six of the failures occurred in igniters subjected to the high temp-low humidity test. There was one failure in the high humidity temp cycle, one in the high temp vibration and one in the low temp storage test. The failure mode in the units subjected to high temp was determined to be asphalt penetration into the black powder of the delay element. Penetration was due to the fact that the melting point of the asphalt used in the delay element was 150°F and the test temp 160°F. Asphalt penetration was confirmed by re-testing igniters having 150°F m.p. asphalt and new igniters having an asphalt melting at 220°F. The test did not include temperature cycling but is considered more severe than the original because 170°F was used instead of 160°F and the exposure time increased. The old igniters had a 100% failure rate at 27 hours and the new igniters a 100% success rate after 144 hours. Results are listed in Appendix IV.

2. Ignition Rate - The ignition rate of the cord exposed to the Low Humidity-High Temp Cycle Test is less than 15 ft/sec as required by contract. There is undoubtedly a slowdown caused by the high temperature. The ignition rate of the cord before testing was 16.2 ft/sec, which is considerably slower than the majority of cord tested during the project. See Appendix II, Forty-Foot Drop Test, for the ignition rate of cord from the same process unit as the two spools subjected to Low Humidity-High Temp Cycle Test. The change in ignition rate is approximately 24% when average values are used for the calculation. Therefore, any ignition rate greater than 20 ft/sec should theoretically pass the test. The average rate for all tests was 27.6 ft/sec.

CONTRACT NO: DAAD05-73-C-0491	ISSUED BY: AB Proving Ground	ADMINISTERED BY:

ITEM NO:	DATA REQUIREMENT:	REPORT PERIOD:	REPORT NO:
A004	Final Report - Phase I, Phase II and Phase III	NA	1

CONTRACTOR: The Ensign-Bickford Company 660 Hopmeadow St., Simsbury, CT 06070	SUBMITTED BY: Michael T. Long Contract Administrator	DATE: November 29, 1973	PAGE 3 OF 3

PRODUCTION (PHASE II AND PHASE III)

By MOD P00001, these two phases were combined and a total of 37,400 feet of Control Agent Smoke Rope was produced together with 775 igniters. Although Phase II and Phase III do not require testing by the contractor, normal representative testing indicated that a portion of the order was slightly slower than the specified 15 ft/sec. This was attributed to the igniter cord axis of the Control Agent Smoke Rope. The igniter cord was at the slow end of its product performance specification. A further 6,000 feet was produced with igniter cord from the faster end of the spec and this new product, which did meet specification requirements, was substituted for the slower portion of the 37,400 feet produced initially.

From this stock, 140 units were produced, each unit consisting of a spool of 250 feet Control Agent CS and five igniters enveloped in an aluminum laminate bag. The bags are heat sealed and enclosed in fiberboard boxes. Four such boxes are combined in each wooden shipping case. There are 35 shipping cases. Gross weight of the shipping case is 75 pounds, net weight of each inner package is 16 pounds.

CONCLUSIONS & RECOMMENDATIONS

The main objectives of the program were fulfilled with little difficulty. It is felt that there are two areas in which further development might be indicated:

1. The igniter is unrefined but functional.

2. The axial igniter cord used makes it difficult to meet the 15 ft/sec burn rate requirement. If this figure is arbitrary it should be relaxed. If not, a faster burning axial igniter cord should be developed.

APPENDIX I

	EBI Cord	Contract Spec
Diameter	.375 ± .010	.250 to .500"
CS Load	3.3 ± .5	2.5 to 10 gm/ft
Smoke Charge	16.5 ± 2.5	7.5 to 30 gm/ft
Total Weight	25.0 ± 5.0	10 to 40 gm/ft
Ignition Rate	27.6 ft/sec avg	15 ft/sec min.
Burn Time	6 sec avg	2 sec min.
Tensile Strength	114.2 lbs avg	64 lbs min.
Cord Color	Blue	Blue
Method of Ignition	Pull wire fuze with 7.0 sec avg delay	Pull wire fuze with 5 sec delay
Smoke Color	White	White
Quantity of Smoke	10' x 10' wall for 2 sec min. in calm wind	10' x 10' wall for 2 sec min. in calm wind

APPENDIX II

SUMMARY - PERFORMANCE TESTING AFTER ENVIRONMENTAL & HANDLING TESTS - CONTROL AGENT SMOKE ROPE

Environmental & Handling Tests	Lot No.	Amount (feet)	Ratio of Igniter Failures to # Tested	Igniter Delay(sec) Avg.	Igniter Delay(sec) Range	Burn Rate(ft/sec) Avg.	Burn Rate(ft/sec) Range	Smoke Cloud Duration Wind Vel. (knots)	Smoke Cloud Duration Cloud Duration	Comments
Low Humidity,High Temp Cycle	35-C	250	2/5	7.4	6.8-8.0	10.5	8.3-14.2	4	60	Pyro powder very dark
" " " " "	35-A	250	4/5	8.2	-------	14.3	10.0-17.8	0	300	" " " "
Low Temp. Storage	36-I	250	0/5	7.3	6.8-8.0	29.1	27.7-31.2	4	60	
	36-K	250	0/5	7.0	7.0-7.2	35.9	33.3-31.6	0	300	
	35-F	250	0/5	7.0	7.0-7.2	25.1	22.7-27.7	0	300	
	36-E	250	1/5	7.0	6.8-7.0	37.1	31.2-31.6	0	300	
Vibration - Low Temp.	36-D	250	0/5	7.1	6.8-7.5	37.1	31.2-41.6	4	60	
	35-D	250	0/5	7.1	6.8-7.5	30.8	22.7-41.6	0	180	
Vibration - High Temp.	36-J	250	0/5	7.0	6.8-8.4	30.3	25.0-33.3	2	60	
	35-E	250	1/5	7.0	7.0-7.2	22.8	17.8-27.7	0	180	
Five Foot Drop	35-H	250	0/5	6.6	6.4-7.0	27.1	20.0-41.6	0	300	
	35-G	250	0/5	6.6	6.4-7.0	30.5	20.8-35.7	0	300	
Forty Foot Drop	35-B	250	0/5	7.1	6.8-7.2	16.2	14.3-19.2	4	60	
High Humidity,Temp. Cycle	36-B	250	0/5	7.2	7.0-8.0	25.3	22.7-26.3	4	42	
	36-A	250	1/5	6.8	6.8-7.0	31.7	29.4-35.7	0	240	
Summary		3500	9/70	7.0	6.4-8.4	27.6	8.3-41.6	---	---	

Note: Testing of material subjected to 40' drop is not required; therefore the Summary does not include this data.

APPENDIX III

CS Aerosolization and Residual After E & H Tests

E & H Test	Amt CS Aerosolized	Amt CS in Residue	Lot No.
High Temp Low Humidity	2.7 gm/ft	0	35-A
High Humidity Temp Cycling	2.88 gm/ft	0	36-B

Frequency of Grass Fire from Smoke Rope

Dry hay about 3 months old was spread on the ground and cord placed on top. Zero ignitions in four attempts. Dry grass was then placed above and below cord. The grass ignited about 15 min. after cord burned.

Frequency of Self-to-Self Ignition

Inch Separation	TEST NO. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	NI	NI	NI	I		NI	NI	I		NI	NI	NI	NI	I		NI	NI	I		NI
1					NI				NI						NI				NI	

NI = No Ignition
I = Ignition

Ignition occurs 25% of the time at 0 separation

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APPENDIX IV

Igniter	Test Temp.	Time Exposure	Ratio Success/Total
Original	170°F	27 hrs.	0/6
Modified	170°F	144 hrs.	40/40
Modified	Ambient	24 hrs.	175/175

APPENDIX V

GENERAL ENVIRONMENTS CORPORATION

TEST REPORT

APPENDIX V

GENERAL ENVIRONMENTS CORPORATION

TEST REPORT

REPORT NO. A-4623

DATE 25 September 1973

REPORT

ON

ENVIRONMENTAL TESTING

OF

TEAR GAS CORDS

FOR

ENSIGN BICKFORD COMPANY
660 HOPMEADOW STREET
SIMSBURY, CONNECTICUT

GENERAL ENVIRONMENTS CORPORATION
HARTWOOD, VIRGINIA 22471

	PREPARED	CHECKED	APPROVED
BY	Wm. P. Dorgeloh	A. A. Ellis	C. M. Hening
SIGNED	Wm. P. Dorgeloh	A. A. Ellis	C. M. Hening
DATE	9-27-73	9-28-73	9-28-73

DATE 25 September 1973

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DATE 25 September 1973

PURPOSE OF TEST:

To expose the packaged tear gas cords to environmental testing.

MANUFACTURER:

Ensign Bickford Company
660 Hopmeadow Street
Simsbury, Connecticut

MANUFACTURER'S TYPE OR MODEL NO.:

Tear Gas Cords

DRAWING, SPECIFICATION OR EXHIBIT:

E. B. P. O. #10304 dated 8-13-73 and GEC Quote # QA-447 dated 2-20-73

QUANTITY OF ITEMS TESTED:

(22) Twenty-two

SECURITY CLASSIFICATION OF ITEMS:

None specified

DATE TEST COMPLETED:

September 14, 1973

TEST CONDUCTED BY: General Environments Corporation
Pyrotechnic Laboratory
Hartwood, Virginia 22471

DISPOSITION OF SPECIMENS:

Returned to Ensign Bickford

ABSTRACT:

See Test Results section

DATE 25 September 1973

TECHNICAL DATA

1.0 Equipment & Apparatus

1.1 Low Humidity, High Temperature Cycle

A. Humidity Chamber
Standard Cabinet
Model: LHHC/27FS
S/N: 1478

B. Temperature-Humidity Recorder/Controller
Bristol
Model: 2S1A500-G1
S/N: 62A3891
Calibration: Due 9-27-73, six month intervals

C. Hygrometer
Hygrodynamics
Model: 15-3000
Calibration: Due 9-18-73, six month intervals

1.2 Low Temperature Storage

A. Temperature Chamber
Standard Cabinet
Model: STACA/36FS
S/N: 2179

B. Temperature Recorder Controller
Honeywell
Model: 602C44-CC-24-III-93
S/N: 59137858012
Calibration: Due 9-29-73, six month intervals

1.3 Vibration

A. Power Amplifier
M. B. Electronics
Model: T51/51-3
S/N: 5317

B. Vibration Exciter
M. B. Electronics
Model: C-20
S/N: 105

DATE 25 September 1973

1.3 Vibration (continued)

C. Accelerometer
Endevco
Model: 2271AM20
S/N: AC04
Calibration: Due 12-2-73, six month intervals

D. Charge Amplifier
Endevco
Model: 2713A
S/N: RA54
Calibration: Due 9-27-73, six month intervals

E. Electronic Counter
Hewlett Packard
Model: 521CR
S/N: 010-03898
Calibration: Due 9-13-73, six month intervals

F. Sweep-Servo-Oscillator
B & K
Model: 1028
S/N: 127824
Calibration: Prior to use

1.4 Five Foot Drop & Forty Foot Drop

A. General Environments Drop Test Facility

1.5 High Humidity Temperature Cycling

A. Humidity Chamber
Standard Cabinet
Model: LHHC/27FS
S/N: 1478

B. Temperature-Humidity Recorder Controller
Bristol
Model: 251A500-61
S/N: 62A3891
Calibration: Due 9-27-73, six month intervals

2.0 PROCEDURES

2.1 Low Humidity, High Temperature Cycle

Two boxes of tear gas cords were placed in the humidity chamber and subjected to the following temperature humidity cycle.

Step 1	Maintain 94°F RH 15% to 20% for six hours
Step 2	Increase to 160°F RH 10% over six hour period
Step 3	Maintain 160°F RH 10% for four hours
Step 4	Decrease to 94°F RH 15% to 20% over eight hour period
Step 5	Repeat 1 through 4 six times
Step 6	Store at +125°F for sixteen hours

The boxes were then removed and inspected externally for degradation due to testing.

2.2 Low Temperature Storage

Four boxes of tear gas cord were placed in the temperature chamber.

The temperature was set to -70°F and maintained for a period of 72 hours. The temperature was then increased to -45°F and maintained for a period of 24 hours. The boxes were then removed and inspected.

2.3 Vibration

Two boxes of tear gas cord were preconditioned at -50°F and two at +145°F. The boxes were then vibrated at their respective temperatures in two axes. The vibration specification was as follows:

2.3 Vibration (continued)

15 minutes/axis for two wheel trailer
1 hour/axis for aircraft

Two Wheel Trailer

Hz	Amplitude
5.5 to 7 Hz	1.0" Double Amplitude
7 to 37 Hz	2.56

Aircraft

37 to 52 Hz	.036" Double Amplitude
52 to 500 Hz	5 G's.

Sweep rate 5-500-5/15 min.

2.4 Five Foot Drop

Two foil packs of tear gas cords were dropped a distance of five feet onto a steel plate supported by concrete.

One foil pack was dropped with the impact across the diameter and the other with impact parallel to the diameter.

2.5 Forty Foot Drop

Eight cardboard boxes of tear gas cord were packaged (four to a crate) in wooden crates. The wooden crates were then banded with $\frac{1}{2}$" steel straps. The crates were then dropped a distance of forty feet onto a steel plate supported by concrete. One crate was dropped on a corner and the other on an end. Photographs were taken of the results and are included in Appendix A.

2.6 High Humidity-Temperature Cycling

Two boxes of tear gas cord were placed within the temperature humidity chamber on stainless steel racks. They were subjected to 10 cycles (240 hours) of the following specification.

FORM NO. 108

2.6 High Humidity-Temperature Cycling (continued)

Step 1 Increase to 105°F 85 to 90% RH over two hour period
Step 2 Maintain 105 ± 3°F 85 to 90% RH for sixteen hours.
Step 3 Decrease to 70°F 95 ± 2% RH over two hour period
Step 4 Maintain 70 ± 3°F for four hours
Step 5 Repeat 1 through 4 ten cycles

The boxes were removed and inspected.

3.0 Test Results

3.1 Low Humidity, High Temperature Cycle

There was no indication of external damage due to testing.

3.2 Low Temperature Storage

There was no indication of external damage due to testing. Frost build up after testing did dampen the cardboard containers.

3.3 Vibration

There was no indication of external damage due to vibration testing.

3.4 Five Foot Drop

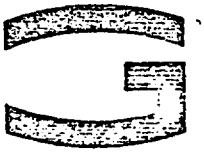
There was no damage to the foil packs due to five foot drop.

3.5 Forty Foot Drop

The wooden crates ruptured on impact as shown in the photographs of Appendix A. The cardboard boxes remained inside the crates.

3.6 High Humidity

Two cardboard boxes became unglued on the ends. All four cardboard boxes absorbed moisture.

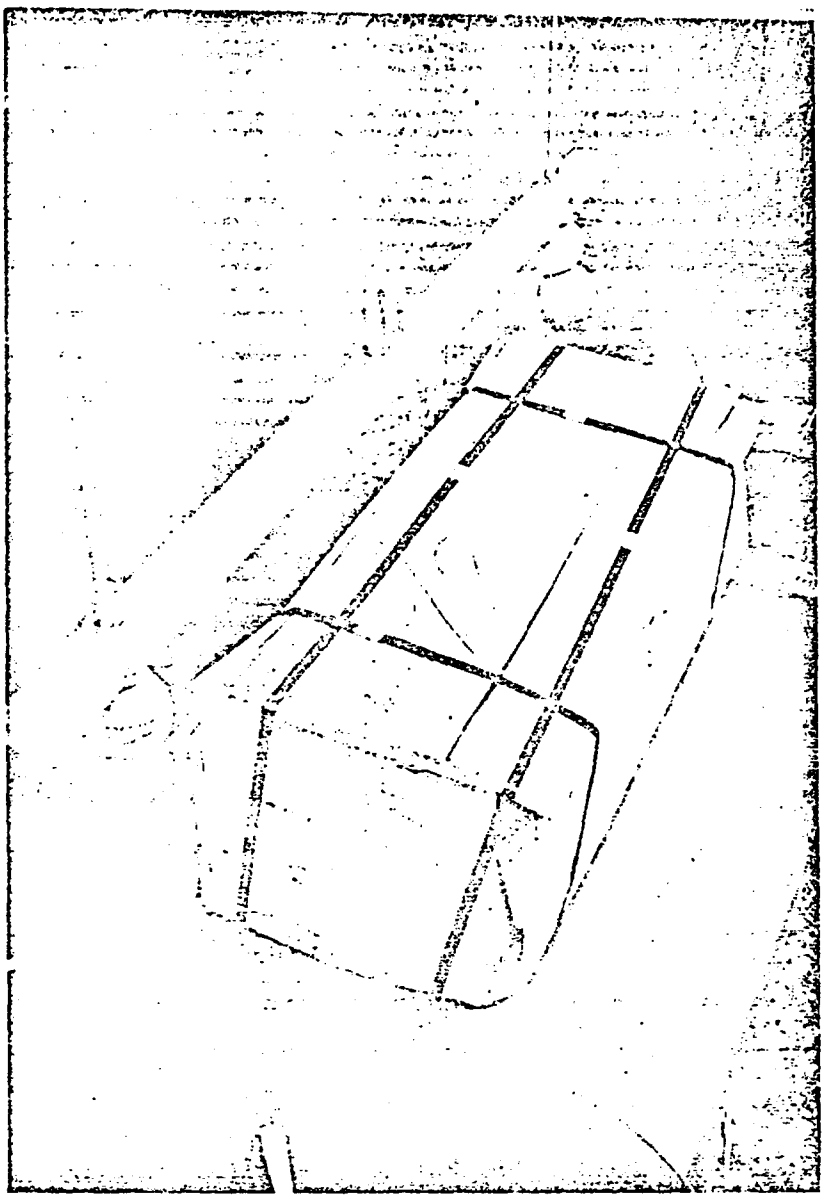


DATE 25 September 1973

APPENDIX A

Photographs

DATE 25 September 1973



FORTY FOOT DROP
END DOWN ORIENTATION

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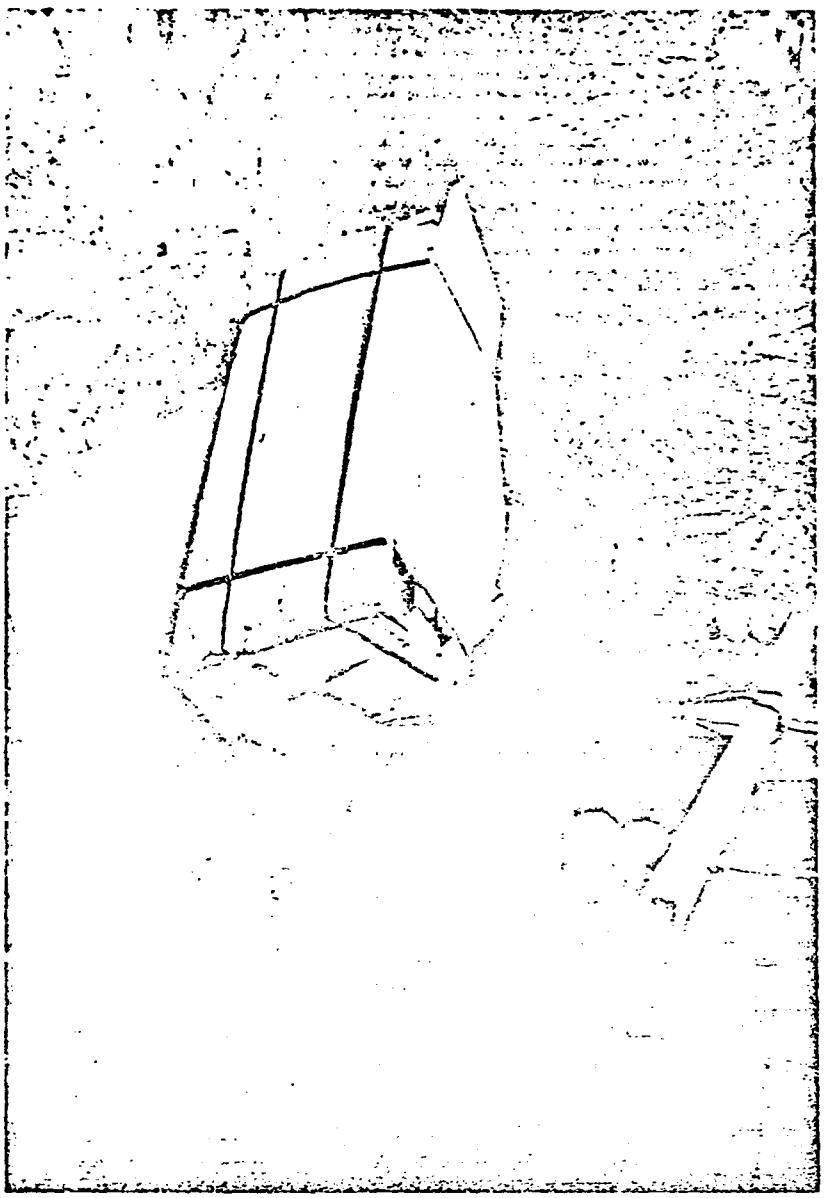

FORTY FOOT DROP
CORNER ORIENTATION

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